CLAIMS:

1. A process for the production of a polymer layer of a flexible unbonded offshore pipe comprising the steps of shaping a polymer material by extrusion into or onto a supporting unit in an extrusion station and cross-linking said extruded polymer material, said polymer material comprising a polyethylene and a peroxide for providing a cross-linking of the polymer material, said peroxide having an activation temperature substantially above, preferably at least 5 °C above, more preferably at least 10 °C above the temperature of the polymer material during the extrusion thereof, said cross-linking of said extruded polymer material being carried out by exposing the extruded polymer material to electromagnetic waves, selected from the group consisting of infrared radiation and microwave.

2. A process according to claim 1 wherein said extruded polymer material is exposed to electromagnetic waves for a sufficient time to thereby raise the temperature of the extruded polymer material at least to the activation temperature of the peroxide.

3. A process according to any one of the claims 1 and 2 wherein the extrusion and cross-linking steps are carried out in an in-line process, including passing the extruded polymer material from the extruder through a cross-linking zone to activate said peroxide to thereby cross-link the polymer material, wherein said activation is performed by applying electromagnetic waves in the cross-linking zone, said polymer material preferably being passed from the extruder to the cross-linking zone with less than 25 °C average intermediate cooling, such as less than 10 °C average intermediate cooling, such as essentially no intermediate cooling.

4. A process according to any one of the preceding claims wherein the supporting unit is a reinforcement layer, preferably a reinforcement layer of the flexible unbonded offshore pipe.

5. A process according to any one of the preceding claims wherein the supporting unit is in the form of a carcass, said polymer layer being an inner liner of the flexible unbonded offshore pipe and said polymer material being extruded onto the carcass.

6. A process according to any one of the claims 1-5 wherein the supporting unit is in the form of a pressure armour, said polymer layer being an intermediate layer of the flexible unbonded offshore pipe and said polymer material being extruded onto the pressure armour.

7. A process according to any one of the claims 1-5 wherein the supporting unit is in the form of a tensile armour, said polymer material being extruded onto the tensile armour.

8. A process according to any one of the preceding claims wherein the polymer layer is an inner liner of the flexible unbonded offshore pipe, said inner liner preferably being extruded into a supporting unit, said supporting unit being in the form of a calibrating device which calibrates the outer dimension of the pipe using vacuum onto a supporting surface.

9. A process according to any one of the preceding claims wherein the polyethylene has a density of at least 920 g/cm^3, such as above 940 g/cm^3, preferably the polyethylene has a density between 945 and 955 g/cm^3.

10. A process according to any one of the preceding claims wherein the polymer material comprises at least 50 % by weight, preferably at least 70 % by weight, more preferably at least 85 % by weight of polyethylene.

11. A process according to any one of the preceding claims wherein the polymer material comprises up to about 10 % by weight, such as up to about 5 % of fillers, preferably selected from the group consisting of pigments, heat stabilisers, process stabilisers, metal deactivators, flame retardants and reinforcement fillers, said reinforcement fillers preferably being selected from the group consisting of glass particles, glass fibres, mineral fibres, talcum, carbonates, mica, metal particles and silicates.

12. A process according to any one of the preceding claims wherein the polymer material comprises up to about 40 % by weight, such as up to about 20 % or preferably up to about 10 % by weight of additional polymer(s) other than polyethylene, said additional polymer(s) preferably being selected from the group consisting of thermoplastics such as thermoplastic elastomers including block copolymer such as SEBS, SBS, SIS, TPE-polyether-amide, TPE-polyether-ester, TPE-urethanes, TPE PP/NBR, TPE-PP/EPDM, TPE-vulcanisates and TPE-PP/IIR; rubbers such as butadiene rubber, isoprene rubber, nitril rubber, styrene-butadiene rubber and urethane rubber; polyolefins such as polypropylene and polybutylene including its isomers; liquid crystal polymers; polyesters; polyacrylates; polyethers; and polyurethane.

13. A process according to any one of the preceding claims wherein the amount of peroxide in the polymer material is at least 0.1 % by weight of the polymer

material, such as between 0.2 and 3 % by weight of the polymer, more preferably up to about 2 % or even more preferably up to about 1.5 % by weight of the polymer material.

14. A process according to any one of the preceding claims wherein the polymer material comprises peroxide from 0.1 to 1.0 % by weight, preferably from 0.3 to 0.8 % by weight.

15. A process according to any one of the preceding claims wherein the peroxide has an activation temperature above 145°C, said peroxide preferably being selected from the group consisting of butylcumyl peroxide, dicumyl peroxide, Trigonox 145B, hydroperoxide, 2,5-dimethyl hexane 2,5-di-t-butyl peroxide, bis(t-butylperoxy isopropyl)benzene, t-butyl cumul peroxide, di-t-butyl peroxide, 2,5-dimethyl hexine-3 2,5-di-t-butyl peroxide and butylhydroperoxide.

16. A process according to any one of the preceding claims wherein the cross-linking is activated by exposing the extruded polymer to electromagnetic waves with a wavelength measured in vacuum of between 0.5 μm and 20 cm, such as between 0.8 μm and 10 cm, such as between 1.0 μm and 1 cm, such as between 2.0 μm and 1000 μm.

17. A process according to claim 16 wherein the cross-linking is activated by application of infrared radiation, preferably the infrared radiation comprising wavelengths in the range 0.5-10 μm, more preferably at least 50 % of the energy applied by infrared radiation is applied in the form of infrared radiation with wavelengths in the range 0.5-10 μm, such as in the range 0.8-6.0 μm, such as in the range 1.0-5.0 μm.

18. A process according to claim 16 wherein the cross-linking is activated by application of infrared radiation, the infrared radiation comprising wavelengths corresponding to the absorption peaks for the polymer material, preferably the maximum intensity of the infrared radiation is in the range 0.5-10 μm, such as in the range 1.0-7.0 μm, such as in the range 3.0-7.0 μm.

19. A process according to any one of the preceding claims wherein the pressure in the cross-linking zone is raised to avoid formation of bubbles and irregularities, said pressure preferably being raised to 1.5 bar, more preferably above 2 bar, such as between 2.5 and 10 bar above ambient pressure.

20. A process according to any one of the preceding claims wherein the extruded material is exposed to the treatment with electromagnetic waves in said cross-linking zone for up to about 600 seconds, preferably for 5 to 120 seconds, more preferably for 10 to 60 seconds.

21. A process according to any one of the preceding claims wherein the extruded polymer material is subjected to a treatment with infrared radiation in said cross-linking zone, the temperature of the polymer material being raised to above 145 °C preferably to a temperature between 150 and 200 °C.

22. A process according to any one of the preceding claims wherein the degree of cross-linking obtained is 75 to 90 %; preferably the degree of cross-linking is 80 to 85 %.

23. A process according to any one of the preceding claims wherein the extruded polymer material enters the

cross-linking zone immediately after extrusion or no later than 2 minutes after extrusion.

24. A process according to any one of the preceding claims wherein the extruded and cross-linked polymer material is cooled to ambient temperatures.

25. A process according to any one of the preceding claims wherein the supporting unit is a metallic material, preferably in the form of a reinforcing layer of the flexible unbonded offshore pipe, which metallic material reflects at least part of the electromagnetic waves applied in the cross-linking zone.

26. A process according to any one of the claims 1-24 wherein the supporting unit is an armour layer of the flexible unbonded offshore pipe, said armour layer comprising a secondary layer, such as a tape applied onto the armour, the polymer composition being extruded onto said tape.

27. A process according to claim 26 wherein said secondary layer is a gas permeation barrier, preferably impermeable to liquid and gas, such as methane, hydrogen sulphides and carbondioxides.

28. A process according to any one of the claims 26 and 27 wherein said secondary layer has a reflective surface reflecting the electromagnetic waves applied in the cross-linking zone, said reflective surface of the secondary layer preferably being capable of reflecting at least 50 % of the not adsorbed electromagnetic waves.

29. A process according to any one of the preceding claims wherein the velocity of the extrusion of the polymer material is approximately equal to the velocity

of the extruded polymer passing through the cross-linking zone, said velocity preferably being between 0.2 to 2 m/minute, preferably between 0.5 and 1.0 m/minute.

30. A process according to any one of the preceding claims wherein the polymer layer is an inner liner of the offshore pipe, said inner liner preferably having a thickness of 4 mm or more, such as 6 mm or more, such as 8mm or more, such as 10 mm or more, such as 12 mm or more, such as 14 mm or more, such as 16 mm or more, such as 18 mm or more.

31. A method for the production of a flexible unbonded offshore pipe comprising one or more polymer layers, one or more of said polymer layers being produced according to the process defined in any one of the claims 1-30.

32. A method for the production of a flexible unbonded offshore pipe, said method comprising the steps of

v) providing a carcass
vi) applying a gas permeation barrier layer onto the carcass,
vii) applying an inner liner in the form of a polymer layer using the process as defined in any one of the claims 1-30 wherein the polymer material is applied onto a supporting unit,
viii) applying one or more reinforcing layers onto the inner liner.

33. A method for the production of a flexible unbonded offshore pipe, said method comprising the steps of

iv) providing an inner liner in the form of a polymer layer using the process as defined in any one of the claims 1-30, wherein the

polymer material is applied into a supporting unit,

v) applying a gas permeation barrier layer onto the inner liner

vi) applying one or more reinforcing layers onto the inner layer.

34. A method according to anyone of the claims 32 and 33 wherein the gas permeation barrier layer is a wound or folded layer of a foil, such as a metal foil, the foil preferably being wound or folded with overlapping edges.

35. A method according to anyone of the claims 32 and 33 wherein the gas permeation barrier layer is an extruded polymer layer.

36. A method according to anyone of the claims 32-35 where said gas permeation barrier layer is sufficiently impermeable to gas to prevent gas such as methane, hydrogen sulphides and carbondioxides at a pressure of 5 bars from diffusing through the layer to its other side with a pressure of 1 bar.

37. A flexible unbonded offshore pipe comprising at least one polymer layer, said polymer layer being obtainable using the process as defined in any one of the claims 1-30.

38. A flexible unbonded offshore pipe comprising an inner liner obtainable using the process as defined in any one of the claims 1-30.

39. A flexible unbonded offshore pipe comprising an outer cover obtainable using the process as defined in any one of the claims 1-30.

40. A flexible unbonded offshore pipe comprising an intermediate polymer layer obtainable using the process as defined in any one of the claims 1-30.

41. A flexible unbonded offshore pipe obtainable by the method as defined in any one of the claims 31-36.